(*b*) Catheterization and aspiration of right auricle, which is proposed with a view to obviate the direct cause of death by the removal of air and spumous blood, thus relieving directly the over-distension of the right ventricle, and, at the same time, to guard against a fatal embolism of the pulmonary artery.

(13.) The results obtained by experiments on animals warrant the adoption of the operative treatment of air-embolism in practice, as a last resort, in all cases where the direct treatment has proved inadequate to meet the urgent indications.

THE FIELD AND LIMITATION OF THE OPERATIVE SURGERY OF THE HUMAN BRAIN.

[Concluded from p. 129.]

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I HAVE now with great detail discussed what I conceive to be the principles of the operative surgery of the human brain. It remains to apply these principles to the treatment of:—

A. Cranial fractures.
B. Intracranial hemorrhage.
C. Intracranial suppuration.
D. Epilepsy following cranial injury.
E. Insanity following cranial injury.
F. Cerebral tumor.

A. In discussing the treatment of cranial fractures, I shall ask myself four questions:

1. What conditions demand incision of the scalp?
2. What conditions render incision of the scalp unjustifiable?

3. What conditions demand perforation of the skull?

4. What conditions render perforation of the skull unjustifiable?

These queries are best answered by the tabulated statement which follows. I admit that the line of treatment advocated is more heroic than that generally taught, but it has been accepted only after careful consideration of the reasoning of those who hold the opinion opposite to my own. Every case must be individually studied, and the patient's chances of death, of life with subsequent epilepsy or insanity, or of return to perfect health, carefully weighed; but for a working rule to guide the student and practitioner, I think experience will show that the indications given in the table are correct. Trephining, when properly performed, is in itself so free from danger that in a doubtful case the patient had better be trephined than allowed to run the risk of death, epilepsy or insanity. Legouest was very nearly right when he said: "Whenever there is a doubt whether trephining should be done, this doubt is probably an indication that operation should be performed."[1]

SYLLABUS OF THE TREATMENT OF FRACTURES OF THE CRANIUM.

CLOSED FISSURED FRACTURES.

1. No evident depression, no brain symptoms. No operation.

2. No evident depression, with brain symptoms. Incise scalp and trephine.

3. With evident depression, no brain symptoms. Incise scalp, and possibly trephine. (See note below.)

4. With evident depression, with brain symptoms. Incise scalp and trephine.

CLOSED COMMINUTED FRACTURES.

5. No evident depression, no brain symptoms. Incise scalp and probably trephine. (See note below.)

6. No evident depression, with brain symptoms. Incise scalp and trephine.

7. With evident depression, no brain symptoms. Incise scalp and trephine.

[1] Lucas-Championnière, *Trépanation guidée par les localisations cérébrales*, p. 23.

8. With evident depression, with brain symptoms. Incise scalp and trephine.

OPEN FISSURED FRACTURES.

9. No evident depression, no brain symptoms. No operation, but treat wound.

10. No evident depression, with brain symptoms. Trephine.

11. With evident depression, no brain symptoms. Possibly trephine. (See note below.)

12. With evident depression, with brain symptoms. Trephine.

OPEN COMMINUTED FRACTURES.

13. No evident depression, no brain symptoms. Probably trephine. (See note below.)

14. No evident depression, with brain symptoms. Trephine.

15. With evident depression, no brain symptoms. Trephine.

16. With evident depression, with brain symptoms. Trephine.

PUNCTURED AND GUNSHOT FRACTURES.

17. In all cases and under all circumstances, trephine.

[NOTE—In classes 3 and 11, I should be inclined to trephine, if the depression was marked, or the fissure sufficiently multiple to approach the character of a comminuted fracture. In classes 5 and 13, I should trephine, unless the comminution was found to be inconsiderable.]

The operation, when decided upon, should be performed at once, or certainly not delayed more than a few hours.

All cases, whether trephined or not, should be treated as cases of incipient inflammation of the brain.

B. In deciding upon operative treatment of intracranial hemorrhages, two questions are to be answered:—

What symptoms render perforation of the skull, in order to remove the clot and secure the bleeding vessels, unjustifiable?

What symptoms demand such operation or render it justifiable?

Intracranial hemorrhages occur between the cranium and dura mater, in the cavity of the arachnoid, in the meshes of the pia mater, in the substance of the brain, and in the ventricles. Hemorrhages within the ventricles, or in the substance of the brain, whether traumatic or idiopathic, must, with our

present knowledge, be treated solely by medical means; though I consider it not impossible that medical science may in time teach us to locate and diagnosticate such lesions with a precision that may justify exploratory and therapeutic operations in a limited number of cases. Blood poured out in the meshes of the pia mater is usually associated with laceration of the brain, and spreads so widely over the surface of the convolutions that it is impossible to locate the origin of the bleeding, or to remove the distributed blood. Hence, operation is contraindicated in cases of intracranial bleeding that do not present the symptoms which are believed to be produced by accumulation of blood in either the cavity of the arachnoid or the space between the skull and the dura mater.

The differential diagnosis between circumscribed hemorrhage within the arachnoid cavity and circumscribed hemorrhage between the dura and cranium is practically impossible, though it is said that marked inequality of the pupils and marked hemiplegia are less noticeable in arachnoid extravasation than in subcranial extravasation. If localized hemorrhage within the arachnoid is reasonably ascertained, trephining with incision of the dura is, in my opinion, justifiable. After the bone is removed, the bluish and non-pulsatile dura will probably bulge into the opening, and should be incised to allow escape of the blood. Nancrede[1] refers to cases where the bulging of the dura did not occur until many hours had elapsed.

It is not likely that any special vessel will require ligation or similar treatment in arachnoid hemorrhage, as does occur, not infrequently, in subcranial hemorrhage, where the bleeding often comes from a large meningeal artery or a venous sinus.

Hemorrhage between the dura and cranium (subcranial extravasation) is not very unusual as an accompaniment of head injuries, because the branches of the large middle meningeal artery ramify over the inner surface of the parietal bone, which from its position so often bears the brunt of the vulnerating force. Indeed, the artery is sometimes, especially at the lower anterior angle of the bone, enclosed in a bony canal, so that fracture of the bone at that point almost insures the laceration

[1] *International Encyclopædia of Surgery.* Vol. 5. P. 51.

of the artery. The venous sinuses are also torn or wounded at times, and cause subcranial extravasation. Hemiplegia on the side opposite the extravasation, rapidly followed by general paralysis and coma, is frequently seen in subcranial hemorrhage. Convulsions during the time of bleeding occur, though not very frequently.

In bleeding from the middle meningeal artery, the clot often causes pressure at the base of the skull, and, therefore, may, by pressure on the cavernous sinus and the nerves going to the eye, cause on the side of injury, protrusion of the ball and dilatation of the pupil, or wider dilatation than in the other eye; while the hemiplegia, from cortical pressure, will be on the opposite side. If a fissure exists, the blood may escape into the temporal fossa of the injured side, and cause tumefaction there. Erichsen[1] records two cases where these symptoms were a valuable aid in diagnosis. Such symptoms, as well as embarrassment of respiration, indicate operation. When the blood lies within the brain, because due to cerebral laceration, the patient has, if the laceration is at all severe, no interval of consciousness after the injury; concussion symptoms soon give place to compression symptoms; and paralysis is not complete as a rule, and is apt to be limited to hemiplegia. Twitching of the limbs, convulsions of the body, restlessness, muttering incoherence, contracted or irregularly dilated and contracted pupils, with perhaps squinting, are the prominent symptoms which occur.

The diagnosis of traumatic subcranial hemorrhage, and, indeed, in a surgical sense, the same may be said of arachnoid hemorrhage also, centres upon the absence of the characteristic symptoms of laceration, just given, and upon the fact that the group of symptoms, commonly called "compression of the brain," occur not immediately after the injury, as in laceration of the brain or hemorrhage into the ventricles or brain substance, but later—that is, after the interval of a few minutes or hours. For example, a man is struck on the head, and falls stunned, but soon recovers consciousness, though subsequently he becomes comatose and paralyzed on the side opposite the

[1] *Science and Art of Surgery.* Vol. I. P. 735.

injury. Here the presumption of a subcranial or arachnoid hemorrhage having occurred, as soon as reaction has sent enough blood to the head to distend the torn vessel, is very great. This period of immunity from head symptoms, after traumatism, is sufficient to justify operative search, when an injury or such symptoms as coma, dilated pupil, hemiplegia, monoplegia or monospasm sufficiently localize the effusion; or if the symptoms are increasing or are of sufficient severity to point to the probability of active encephalitis. Apoplexy, drunkenness, opium-poisoning, uræmic coma and intracranial hemorrhage are often to be differentiated in cases without history. The problem is frequently difficult. Reference has been made, on p. 123, to Dr. Seguin's suggestion regarding the diagnosis of latent apoplectic paralysis.

A very short interval indicates rapidly flowing hemorrhage, and demands early operation, with probable ligation of the middle meningeal artery or one of its large branches, or ligation or compression of a sinus. It must be remembered, also, that compression symptoms, coming on immediately or quite soon after depressed cranial fracture, are very often due to the subcranial clot, rather than the depressed bone. Removal or elevation of bone is often needed more for liberation of blood-clot and control of hemorrhage than because of deformity in the bony outline.

Rapid hemorrhage will probably be from the middle meningeal artery, and, therefore, a large trephine should be put over the anterior inferior angle of the parietal bone and the squamous portion of the temporal bone just below that angle, unless the localizing symptoms direct to some other point. Inspection of the skull will show that the two large branches of this artery, as they ascend to distribute branches to the lateral region of the cranium, can both be uncovered by a large trephine applied to this point.

This point is situated about $1\frac{1}{2}$ inches behind the external angular process of the frontal bone, and one inch above the zygoma; or $1\frac{1}{2}$ inches directly above the condyle of the jaw.

The rules given by Keen and Erichsen[1] are accurate for un-

[1] Holden's *Medical and Surgical Landmarks.* Edited by W. W. Keen. Phila. 1881. P. 18. Erichsen's *Science and Art of Surgery.* Vol. I. P. 739.

covering the superior branch, but place the trephine, I think, a little too high, if the two branches are to be uncovered at their point of divergence. There are probably variations of the point of bifurcation. The bleeding vessel, when found, may be ligated or twisted, or the bony canal plugged with a piece of stick or wax, or the actual cautery applied by means of a red-hot needle. (See cut on p. 127.)

Nancrede[1] has collected forty cases of operation of this kind, with 24 recoveries and 16 deaths. Early operation gave, as might be expected, a much better percentage of recovery than those in which operation was delayed.

The tendency has been to deter surgeons from operating in intracranial extravasations, unless the certainty of diagnosis was great. For example. Gross says:[2] "The only case in which such a procedure is really warrantable is where the extravasation is associated with, or dependent upon, fracture of the skull, complicated with depression, or serious injury of the soft parts, or where the fracture is situated directly over the course of the middle meningeal artery." This advice is, in my opinion, too restrictive. Gradually increasing brain symptoms, after head injury, especially if there has been a period of return to consciousness after the shock of traumatism, suggests the occurrence of intracranial bleeding from meningeal vessels, even when no fracture or depression of bone is detectable. Operation is then especially indicated, if the localizing symptoms point to no other region of the cortex and if symptoms such as described above, on page 218, do not render cerebral laceration probable.

C. I come now to the operative treatment of intra-cranial suppuration.

I believe that operative evacuation should be undertaken in all cases of localized intra-cranial suppuration, whether the abscess is sub-cranial, intra-meningeal, or cerebral.

Ashhurst[3] and some other authorities rather deprecate operation, because patients have lived a long time with cerebral abscess in a quiescent encysted state; and perhaps also because

[1] *International Encyclopædia of Surgery.* Vol. V. P. 48.
[2] *System of Surgery.* Ed. 1882. Vol. II. P. 55.
[3] *Principles and Practice of Surgery,* p. 326.

autopsies have in rare instances shown what appear to be abscesses of the brain cured by caseation. The tendency, however, of intra-cranial suppuration, whether diffuse or localized, is known to be toward death. Cerebral œdema by progressive invasion of vital centres, rupture of the abscess into the ventricles, and extension to the surface of the base where fatal meningitis occurs are the usual modes of destroying life. Spontaneous evacuation through the nares, orbit, ear, or bony wall is too rare to be expected in any given case. Absorption, as far as we know, never occurs.

The difficulty in every case is that of establishing a diagnosis of pus and of proving that the pus, if present, is not a diffused meningeal exudation on the surface of the brain. The occurrence of symptoms indicative of intra-cranial suppuration within a few days of the receipt of a cranial injury usually means diffuse meningeal suppuration and contra-indicates efforts at evacuation. Symptoms of intra-cranial suppuration occurring at a later period are more apt to be due to abscess in the cerebral tissue or to a localized pus collection between the bone and the membranes, and therefore indicate more decidedly the propriety of operation with a view to evacuation.

Intra-cranial suppuration, such as may be benefited by operation, provided that the exact situation of the pus can be diagnosticated, is apt to present a combination of some of the following symptoms:—

1. Headache, or a subjective sense of pressure on the brain. The headache is perhaps usually dull, and when present is quite constant.

2. Giddiness, nausea, or even vomiting.

3. Mental hebetude, dullness of senses, slowness in speech and movements, aphasia, mental irritability, muttering delirium, increasing imbecility.

4. Constipation.

5. Paresis, sensory abnormalities.

6. Sleeplessness, optical delusions, attacks of terror.

7. Chills.

8. General convulsive seizures of an epileptiform character; sometimes in a few cases localized convulsions.

9. Little, if any, elevation of general bodily temperature.

10. Perhaps localized increase of surface temperature of the head.[1]

At a later period there will occur most probably—

1. Hemiplegia.

2. Perhaps active delirium, severe headache, high temperature, especially if meninges become involved secondarily.

3. Coma.

4. Passive retinal congestion.

5. Involuntary evacuations.

6. Slow and full pulse, dilated or sluggish pupils.

7. Respiratory failure.

8. Death.

The symptoms of chronic abscess may be so insidious as to escape notice of all except a very careful observer. It has been said that there are at times no symptoms. This I doubt, believing that a critical examination will detect them, especially if the observer be trained in investigating nervous diseases, and be sufficiently intimate with the patient to have known his previous habits and mental characteristics.

Puffy swelling of the scalp and separation of the pericranium with dry and yellow bone beneath it, seen at the bottom of a head wound, will in some few cases be found, and with general symptoms of pus become a clear evidence of abscess beneath the bone at that spot. Symptoms such as just mentioned demand trephining. If the pus is not found beneath the bone and the dura is pulseless and bulging, that membrane should be incised. If no pus is discovered and the general symptoms of intra-cranial abscess are marked, exploratory puncture and aspiration of the brain should then be performed.

In some cases surface thermometry may indicate the point on the cranium nearest the focus of suppurative encephalitis.

Nancrede[2] believes that when an intra-cranial abscess involves cerebral tissue alone the general bodily temperature is subnormal, or at least it is not an elevated temperature. He

[1] The suggestions of Flitner to measure the temperature of the external auditory meatuses by a properly constructed thermometer, might be utilized. See *Journal of American Medical Association*, November 15, 1884.

[2] *International Encyclopædia of Surgery*, Vol. V., p. 86.

looks upon high temperature as an evidence of localized suppurative arachnitis or of meningitis in addition to the cerebral abscess. Cerebral abscess, secondary to bone disease, would, of course, be liable to present an elevation of temperature, because meningitis was an early concomitant.

If a majority of the symptoms tabulated as accompanying intra-cranial abscess exist, and there has been received an injury on the side of the head opposite the hemiplegia, to which the supposed abscess can with reason be attributed, an exploratory operation should be done at the point of injury.

If the said symptoms exist and the principles of cerebral localization indicate any special region of the cortex or brain substance, an exploratory operation should be done on that part of the skull that affords best access to the supposed seat of lesion.

Incision of the membranes and exploratory puncture of the brain substance with aspirating tubes to the depth of three or more inches in various directions is justifiable if the symptoms of abscess are undoubted. The abscess cavity or cavities, when found, should be drained by free openings and counter-openings and drainage tubes, and should even be washed out by hydrostatic irrigation, if it is probable that there are pockets in which pus may remain and decompose.

Scarcely any limitation should be dogmatically given regarding the operative search for pus in undoubted abscess of of the cerebral tissue, so long as the aspirating tube is not thrust deeply towards the vital centres located in the medulla oblongata and base of the brain. It is never too late to seek for the pus, for Nancrede[1] gave a patient several days of life after he was thought by several competent observers to be dead, by promptly incising a cerebral abscess. The earlier the operation is done the better; but it is never too late to make the attempt at evacuating an intra-cranial cranial abscess.

D. In epilepsy following injury much good may at times be effected by removal of the cranial wall at the site of traumatism.

An internal spicule or osteophyte, from depressed or chron-

[1] *International Encyclopædia of Surgery*, Vol. V., p. 84.

ically inflamed bone, penetrating or pressing upon the membranes, thickened bone, pathological changes in the membranes themselves, the existence of a sequestrum of necrotic bone, depressed and neuralgic cicatrices of the soft parts, and similar kinds of irritation may be the exciting cause, giving rise to epilepsy in patients whose convulsive centres are especially irritable. Briggs has seen cases of epilepsy in which narrow spurs of bone nearly a half inch long grew from the inner surface of the skull.[1] Removal of the cause by operation is in such cases certainly demanded. Epilepsy due to peripheral irritation of a cicatrix in the scalp without bone lesion, may be relieved by dissecting out the scar tissue or detaching it as a flap from the bone, and allowing healing by granulation to occur. The application of the actual cautery to the scar may perhaps destroy the focus of irritation; though in a case where I tried this method no relief was obtained.[2]

Cauterization or excision of scar tissue should be attempted in traumatic epilepsy, therefore, before resort is had to trephining, except, perhaps, in cases where there is an evident accentuated depression of the bone. Then the irritating cause of the convulsions is not likely to be in the soft tissues alone. The subject of trephining in epilepsy was so ably and thoroughly handled at the last meeting of the Association by our present President, Dr. Briggs,[3] that I shall do little more than repeat some of his statements, and add a few thoughts which may serve to impress the Fellows with the importance of the topic, and cause them to again read his valuable paper.

The development of epileptic convulsions requires, first, a persistent abnormal excitability of the centres in the medulla oblongata and pons Varolii; and secondly a peripheral irritant. The latter is the exciting cause, and may be hard to discover in any given case. Traumatism often furnishes the peripheral irritant in the existence of a sensitive scar in some part of the head or body, or a cranial lesion irritating the cerebral membranes or brain. The hyper-excitability of the medulla and pons may be inherited, or acquired through personal acci-

[1] See Duret's paper on Dura Mater to which reference is made on p. 128.
[2] See *Transactions American Surgical Association* (1884), p. 132.
[3] *Transactions American Surgical Association*. 1884.

dental causes. Echeverria[1] attributes ten per cent. of all epilepsies to injuries of the head; but it must be remembered that the convulsions may not be developed for years after the injury. Briggs has seen cases in which ten years had elapsed; and quotes a case of Dudley's which developed sixteen years after injury, and was entirely cured by trephining. I must admit, however, that Althaus[2] has stated that fourteen years experience in a hospital devoted to epilepsy has taught him that traumatic epilepsy is rare. If operative treatment is instituted for traumatic epilepsy all the diseased or depressed bone should be removed. Briggs has taken away the cranial wall covering an area as large as the palm of the hand, and cured the epilepsy without causing any unpleasant symptoms.

From tables of the operation collated by Stephen Smith, Billings and Echeverria,[3] 92 American operations are reported, of which 63 were cured, 13 ameliorated, 2 not changed, 14 died. Walsham[4] has collected 82 cases, to which he has added 48 collected by Billings and others, making 130 in all, of which number 75 were completely cured, 18 improved, 7 unimproved or worse, 30 died. Thirty cases of epilepsy from old injuries of the head have been operated upon by Briggs; of these 25 were cured, 3 ameliorated, 1 not changed, and 1 died.

In 48 of the 82 cases collected by Walsham[5] himself, cure was effected; 13 were relieved at the time of the report, 4 were not improved and 17 died, which gives a death rate of 20.7+ per cent.; but some of the deaths occurred so long after the operation as to be scarcely attributed with justice to the operation.

Nancrede[6] says that after adding 37 cases collected by himself to the whole number collected by Walsham (130), he finds in the 167 cases a mortality of 19.16 per cent., but does not describe the kind of cases in which death occurred.

Cure has in a number of cases followed operation, though

[1] Briggs, *Transactions American Surgical Association*, 1884.
[2] *Amer. Jour. Med. Sciences*, January, 1880, p. 270.
[3] Quoted from Briggs.
[4] *St. Bartholomew's Hospital Reports* (1883), p. 130.
[5] *St. Bartholomew's Hospital Reports* (1883), pp. 130 and 136.
[6] *International Encyclopædia of Surgery*, Vol. V., p. 101.

no pathological change was recognized in bone or membranes.

In epilepsy and insanity from traumatic causes connected with the skull, the lesions appear, according to Walsham,[1] to have generally existed in the anterior half segment of the cranium. The symptoms justifying operation are cicatrices which are sensitive, tender, and abnormally hot by the surface thermometer; pain or sense of brain pressure at the seat of old injury, which may not be constant, but which is always, when present, referred to the same spot; pain, vertigo, or convulsions produced by pressure upon the cicatrix; depressions or elevations in the bone; fistulas leading to necrotic bone, and any symptoms indicating, through study of cerebral localization, brain lesion in the region of the external scar. Operation seems to me to be especially indicated in these cases if the scar is in front of the middle of the cranium.

The symptoms contra-indicating operation on the head are the existence of other foci of irritation, as in one of Briggs' patients, who had a depression of the skull and diseased bone in one leg, and in whom the removal of the necrotic tissue in the leg cured the epilepsy without any surgical interference with the head. The absence of pain, tenderness, or other symptoms of irritation, the history of epilepsy in other members of the family, or a short period of medicinal treatment, would be facts that should cause hesitation in operation until every other means has been employed, or until the progressive character or the severity of the epilepsy forebodes early impairment of intellectual functions.

If operation fails to relieve, it may be repeated near the old spot of operation after the lapse of several months; for at least one case is known where operation was ineffectual, and subsequent autopsy showed a fragment of bone pressing upon the encephalon. Removal of this would probably have cured the epilepsy. Several months time must elapse before the operation is declared unsuccessful; for the brain does not always give up its convulsive habit at once. Subsequent treatment to relieve the hyper-excitability of the medulla and

[1] On Trephining the Skull in Traumatic Epilepsy, *St. Bartholomew's Hospital Reports* (1883), p. 139.

pons, and to remove any other causes of peripheral irritation, must be judiciously carried out. The cicatrix left after trephining may become a secondary peripheral irritant, and need excision to relieve pinched nerve filaments. I know, however, of no such case on record.

How long should operation be delayed in epilepsy presumably caused by a depressed fracture of the skull or other localized traumatic irritant? Certainly not at all after the diagnosis of the cause has been made, provided that medical means have been efficiently tried and have failed. Operations done promptly prevent an increased development of abnormal excitability in the convulsive centres, and give, therefore, the best chance of recovery from the epileptic manifestations. Mental deterioration increases with the lapse of time, as does in my opinion the risk of serious cerebral reaction after operation. A normal nervous system would be less likely to assume inflammatory symptoms dangerous to life than would a nervous tissue long subjected to irritating influences.

If the epilepsy cannot be definitely attributed to the traumatism, which by the history and by the scar is known to have occurred, I should advocate an empirical operation in the course of five or six months, or even earlier; provided that no other cause is discovered, that medicinal treatment has proved unavailing, and that the epilepsy is increasing in severity.

E. Operations for the relief of insanity due to cranial traumatism have not been very generally advocated or attempted. One year ago Dr. William A. Byrd[1] brought the subject to the attention of this Association, and referred to four cases which were trephined for insanity after fractured skull. Three were operated upon by Dr. W. T. Briggs, the fourth by Dr. Byrd himself. Dr. Byrd's case improved for a short time, and then became progressively worse in regard to her mental condition. Two of Dr. Briggs' cases entirely recovered their mental health; one was a boy, the other a man who had received a gunshot fracture above the ear. The third of Briggs' cases was an almost hopeless one, which he had at one time declined to subject to operation. The lamentable condition of the im-

[1] *Transactions American Surgical Association* (1884), p. 130.

becile patient and the solicitations of the family finally induced him to operate. Death occurred on the second day after, "a rigor followed by great depression."

In the discussion following Dr. Byrd's paper, I find Dr. T. F. Prewitt[1] is reported as having spoken of trephining an insane woman, who was relieved only for a time. The report here is incorrect, for Dr. Prewitt has written me that he has never trephined for insanity. The remarks, I think, should be ascribed to Dr. Byrd, and refer to his case, which formed the subject of debate.

I find a case of insanity cured apparently by operation, mentioned by Dr. L. A. Stimson, and another by Dr. J. L. Little.[2]

In his elaborate table of trephining cases, Amidon[3] refers to McCormick's case of acute mania, occurring eight years after a depressed cranial fracture, which recovered after the depressed area of bone was removed by operation. In this instance there was pain at the site of wound, which was situated at the junction of the sagittal and coronal sutures.

With so few cases as are reported, it is difficult to formulate dogmatic rules. It seems to me, however, that the operation of removing a portion of the cranium is justifiable when, within a few months after a depressed fracture of the skull, progressive mental aberration occurs in a previously sane patient who presents no other assignable cause for the intellectual malady. If there is pain or tenderness at the site of the injury, or if motor or sensory phenomena are found in the regions supplied by the nervous centres situated under the seat of the injury, the demand for operation is much more imperative. I admit that cases reported as cured of acute maniacal symptoms by trephining are doubtful cures, because they might have recovered without operation. A number of chronic cases recovering after operation would afford much more conclusive evidence of the value of operative therapeutics.

Operation should be done before the pathological changes cause great imbecility. If pressure causes local degeneration

[1] *Transactions American Surgical Association*, p. 134.

[2] *Annals Anatomy and Surgery*, VIII. (1883), p. 137.

[3] *Annals of Surgery*, March, 1885, p. 211, quoted from *American Practitioner* XXVII. (1883), p. 237.

or atrophy of the cerebral convolutions, it is imperative to remove that pressure as soon as it is evident that remedial drugs afford no relief, and that the mental impairment is progressive. In an early part of this paper I have referred to a case seen by Dr. Mills and myself, in which I was prepared to trephine as soon as it was clearly established that the mental deterioration had no other assignable cause than the depressed fracture. Unfortunately the patient passed from observation.

It is impossible to fix any time; but progressive failure during three months would incline one to operate, and the same conditions during six months would, I think, justify the surgeon to very strongly urge surgical treatment. On this point, however, I should like to hear the views of the Fellows of the Association.

In operating, all the depressed bone should be removed, by cutting away the intervening bone between the holes made by numerous applications of the trephine. Hey's saw, the gnawing forceps, or the burr attached to the surgical engine will accomplish this. Guthrie [1] refers to a case of fracture, but not of insanity, in which twelve disks were removed before the depressed bone was properly elevated. Recovery followed.

Operation is not justifiable when there is evidence that some degree of insanity existed before the injury, nor when the patient has had, previously to the injury, insane delusions, not traumatic, from which he had recovered before the traumatism; nor when the character of the insanity is such that the pathological change is probably located in a region of the brain distant from the seat of injury; nor when the insanity involves so many intellectual functions that general cerebral disease is clearly existant.

F. Operations for the removal of cerebral tumors have, as far as I know, been attempted only recently. The fear of approaching the brain with instruments deterred surgeons in a manner that seems unaccountable, when we recall the numerous instances of recovery from accidental brain injuries that have been reported during the past fifty years. It is probable that the most of those which recovered were of a character

[1] Gross, *System of Surgery*, Vol. II., p. 88.

that insured efficient drainage, and that we did not have discernment enough to realize the true method by which fatal results were averted.

Primary cerebral tumors which are not controlled by medical treatment are usually single, seldom give rise to secondary deposits, are generally surrounded by an inflammatory zone of demarkation, and continue to increase in size until they destroy life. Therefore, when they are believed to be upon or in the cortex of the brain, or at least not deeply located in the cerebral substance, they should be removed by operation, unless they are in some such inaccessible and especially dangerous region as that at the base of the brain. Amidon[1] was one of the first, if not the first, to insist upon this method of dealing with cerebral tumors. A few months ago Godlee removed by enucleation a glioma the size of a walnut, situated a quarter of an inch below the surface of the ascending frontal convolution, which had been located by Bennett.[2] For 20 days the patient did well, but he died on the 28th day from meningitis at the lower part of wound spreading down towards the base of the brain on same side, the whole of which was inflamed and covered with plastic lymph. The rest of the brain was normal.[3]

Amidon justly asks whether death might not have been due to the absence of antiseptic precautions and the want of provision for drainage; especially as the galvano-cautery was used to stop bleeding. I am not aware that the operator has definitely stated whether antiseptics were adopted and provision for drainage made.

This remarkable case of sagacious diagnosis by cerebral localization followed by a well planned surgical operation is certainly very encouraging, and will doubtless be the incentive which will save many lives.

Multiple cerebral tumors, tumors of the base, cerebral growths secondary to neoplasms in other localities should not be subjected to operation. If other circumstances obtain, and the symptoms are such as will localize the growth with reasonable certainty excision should be attempted.

[1] *Medical News*, June 21, 1884.

[2] *Lancet*, December 20, 1884, and January 3, 1885.

[3] See Amidon's discussion of its details in *Annals of Surgery*, March, 1885.

Sands[1] records a remarkable case, in which Dr. R. W. Amidon diagnosed traumatic epilepsy in a patient who had struck the left parietal region against a sharp corner, but in which trephining showed no bony lesion. Death occurred in eight days, and a gummy tumor, which could probably have been removed, was found directly beneath the seat of trephining. No evidence of meningitis from the operation was apparent. This case may have been a potent factor in determining Dr. Amidon's well known advocacy of the enucleation of cerebral tumors.

Dr. Charles K. Mills, who has made at least 25 or 30 autopsies in cases of brain tumors, and of which number twelve have been published,[2] has called my attention to the fact that in several of them removal of the tumor would have been readily possible.

I give from his paper an abstract of two cases:

CASE 4. Clinical History: Female, æt. 30. No history of causation. Headache, continuous, sometimes agonizing. Percussion of head caused most pain in right parietal region. Vomiting when headache was most severe. Vertigo. Mind clear, but acted slowly; emotional. Spasm, beginning with twitching of fingers of left hand; most severe on left side, and especially in left arm. Upper as well as lower fibres of left facial nerve partially paralyzed; nearly complete paralysis of left arm; slight paralysis of left leg. Bowels and bladder partially paralyzed. Impaired sensibility in limbs of left side. Left patellar reflex diminished. Sight very imperfect. Choked disks. Hearing defective in right ear.

Pathological Anatomy. Carcinoma. About 1½ inches in diameter beneath and adherent to the pia mater of the convexity of the right hemisphere; the pia and dura mater were united by strong adhesions. The tumor involved the middle portion of the ascending parietal convolution and the upper part of the inferior parietal lobule, pushing aside the inter-parietal fissure. The anterior extremity of the tumor was about one-fifth of an inch back of the centre of the fissure of Rolando. On the inner side of the tumor the white matter of the brain was broken down.

CASE 5. Clinical History: Female, æt. 38. History of syphilis. Blows on the head. Headache, with agonizing paroxysms. Top and right side of head sensitive to percussion, and headache severest in these regions. Vomiting. Vertigo. Great mental irritability. Severe left-sided spasm, beginning with twitchings in left toes and foot. Partial paralysis of right leg and arm, most marked in leg. Hyperæsthesia. Impaired sight. Choked disks. Head temperature taken once—right parietal region, 97.2° F.; left parietal region, 96° F.

Pathological Anatomy. Gumma. Attached to the frontal membranes of the right convexity. Involved the upper fourth of the ascending frontal, and a smaller segment of the ascending parietal convolution, crossing the fissure of Rolando at its upper extremity. A good example of strictly cortical lesion, involving only gray matter, and having only a very thin layer of softened tissue on its inner side. Micro-

[1] *Annals of Anatomy and Surgery*, Vol. VIII. (1883), p. 113.

[2] *Archives of Medicine*, August, 1882.

scopical examination of the optic nerves showed the appearances of choked disks, with probable ascending neuritis.

I have thus considered most of the topics which may be included under the head of cerebral surgery. In fractures, hemorrhage, and abscess perforation of the skull will soon become quite common. In epilepsy, insanity, and tumor the profession will be more tardy in opening the skull. While I am sure that these conditions, in certain instances, can only be treated successfully by operative procedure, I believe, also, that other cerebral conditions, less well defined in pathology, such, for example, as incurable and intolerable headaches after injury, may in time be justifiably subjected to similar operations.

For such operations upon the skull and brain, proper instruments should be at hand. For uncovering the centres of motion, in searching for suspected lesions localized by symptoms, a trephine removing a disk 3 centimetres in diameter is none too large, for then both ascending convolutions and the intervening fissure of Rolando can be inspected with ease. A trephine with a cutting edge along only a half or two-thirds its circumference would, I think, be convenient at times for deepening a groove on one side of the disk, when the remaining portion of the circular groove has already cut through the bone in a thinner spot; and also for enlarging a trephine hole previously made. Dr. W. B. Hopkins has suggested a modification of the trephine which may be of value in this connection.[1] A probe with a large olive shape head and a light aluminium shaft, as recommended by Fluhrer, is certainly the proper exploring instrument in gunshot wounds of the brain. The head should, as he suggests, be placed so that the probe will be vertical and drop into the wound by its own weight. Aspirating needles should probably be made with a round end, and a lateral opening like a catheter.

Appended will be found tabulated statements of I. *The indications for operation in traumatic cases;* II. *Contra-indications;* III. *Points for opening the cranium when operation is indicated;* and, IV. *Uncertain localizations.* In the order of the argument, these belong at the end of that portion of the memoir which appeared in the last issue.

[1] *Annals of Surgery.* July, 1885.

TABLE I.—INDICATIONS IN TRAUMATIC CASES.[1]

1. Hemispasm or 2. Incomplete hemiplegia or 3. Hemispasm with hemiplegia,	On the opposite side of the body after even slight injury in the fronto-parietal region, and even when not directly over the motor area,	Indicates exploratory operation at the seat of the injury.
4. Monospasm or 5. Monoplegia, whether total or incomplete,	Ditto, ditto,	Indicates, indeed demands, exploratory operation at the site of the injury.
6. Hemi-hyperæsthesia or 7. Hemi-anæsthesia or 8. Hemi-analgesia or 9. Hemi-hyperæsthesia with anæsthesia or hemi-analgesia,	On the opposite side of the body after even slight injury in the parieto-occipital region near or somewhat behind the motor area,	May indicate exploratory operation at the side of injury.
10. Mono-hyperæsthesia or 11. Mon-æsthesia or 12. Monalgesia,	Ditto, ditto,	May indicate, or may perhaps demand, exploratory operation at the site of the injury.
The twelve symptoms above mentioned, if on the same side as the injury, contraindicate operation at the site of the injury, but		May indicate exploratory operation on the side of the cranium opposite the injury.
13. Coma with hemispasm or hemiplegia,	In cases of supposed subcranial or arachnoid hemorrhage,	May indicate exploratory operation on the side opposite the paralysis or spasm.
14. Coma with hemi-hyperæsthesia or hemi-anæsthesia or hemi-analgesia,	In cases of supposed subcranial or arachnoid hemorrhage,	May indicate exploratory operation on the side opposite the hyperæsthesia, anæsthesia or analgesia.

[1] See Notes on Dura Mater and its Lesions.

TABLE II.—CONTRA-INDICATIONS.

1. Paralysis of one or more cranial nerves, Neuro-retinitis, Cheyne-Stokes respiration, or Other symptoms showing lesions probably at the inaccessible base of the brain, or in undeterminable parts of its interior,	Even if other symptoms indicate operation, are, except in cases of supposed cerebral abscess,	Contra-indications to exploratory operation.
2. Complete hemiplegia; which often is not of cortical origin, but is due to lesions of deep structures,	Is, except when 1. It is due to a supposed cerebral abscess; 2. It has been incomplete at outset; 3. It is irregular and corresponds with extensive depression of bone on opposite side of cranium,	A contra-indication to exploratory operation.
3. Hemispasm or hemiplegia with marked hyperæsthesia or anæsthesia indicates more extensive cortical lesion than hemispasm or hemiplegia alone, and may even be due to deep lesions,	Is, except when 1. The hyperæsthesia or anæsthesia is limited to a small surface (monæsthesia); 2. Hyperæsthesia or æsthesia is apparently due to the same cortical lesion that causes the spasm or paralysis,	A contra-indication to exploratory operation.
4. Hemispasm or Hemiplegia on same side as injury,	May, if other symptoms indicate operation, be an indication for operation on the side of the cranium opposite that of the injury, but	Is a contra-indication to exploratory operation on the injured side of the cranium.
5. Complete anæsthesia (?),	. . . . .	. . . . .
6. Hemi-hyperæsthesia or Hemi-analgesia, with marked spasm or paralysis, indicates more extensive cortical lesions than hemi-hyperæsthesia or hemi-anæsthesia alone and may even be due to deep lesions,	Is, except when 1. The spasm or paralysis is limited to a small group of muscles (monoplegia); 2. The spasm or paralysis is apparently due to the same cortical lesion that causes the hyperæsthesia or anæsthesia,	A contra-indication to exploratory operation.
7. Hemi-hyperæsthesia, or hemi-anæsthesia or hemi-analgesia, on same side as injury,	May, if the other symptoms indicate operation, be an indication for operation on the side of the cranium opposite to that of the injury, but	Is a contra-indication to exploratory operation on the injured side of the cranium.

NOTE.—When the symptoms indicate that many centres are involved—and this is usually the case—more bone must be removed than by a single large trephine perforation. The burr of the surgical engine or the gnawing bone forceps are the most convenient instruments for enlarging the trephine hole.

TABLE III.—POINTS FOR OPENING THE CRANIUM WHEN OPERATION IS INDICATED.

Symptoms.	*Probable Area of Cortex Involved.*	*Points where Brain should be Uncovered.*	*Remarks.*
Hemispasm or Hemiplegia.	Along entire length of fissure of Rolando or possibly along a portion of its extent, and involving other areas secondarily. More probably in front rather than behind fissure.	Over middle fissure of Rolando, and to be extended downwards, upwards, and forwards in search for lesions, rather than backwards, unless disturbances of sensation have been present; then backward extension is indicated. If aphasia is present, the opening should be extended downwards and forwards.	
Crural Monospasm or Monoplegia (convulsions or paralysis limited to one leg or part of one leg).	Upper third of central region in ascending convolutions, and astride of upper end of fissure of Rolando. Possibly in front rather than behind fissure (?). Some say, in ascending parietal convolution rather than in frontal. (See Erichsen, vol. i., p. 725, and Lucas-Championnière.)	Over upper end of fissure of Rolando, and to be extended forwards rather than backwards, unless disturbance of sensation is present.	
Spasm or paralysis of both legs, not due to spinal lesion.	Upper part of central region and paracentral lobules on both sides.)	Over middle line between upper ends of both fissures of Rolando; to be extended towards the side of vault of cranium which is opposite to the side of the more pronounced symptoms. Take care to avoid, if possible, injury to superior longitudinal sinus.	
Brachial monospasm or Monoplegia (convulsions or paralysis limited to one arm or part of one arm).	Middle third of central region in ascending convolutions, especially in ascending frontal.	Over middle third of fissure of Rolando; but rather more in front than directly over the fissure, though the fissure should be uncovered. To be extended forwards rather than backwards, unless disturbance of sensation is present.	Facial spasm or paralysis is often associated with the crural symptoms, as by hemorrhage gravitating downwards, etc.
Associated crural and brachial monospasm or monoplegia.	Upper two-thirds or at junction of upper and middle thirds of central region, probably in ascending frontal rather than in ascending parietal convolution.	Over junction of upper and middle thirds of fissure of Rolando.	

TABLE III.—POINTS FOR OPENING THE CRANIUM WHEN OPERATION IS INDICATED. (*Continued.*)

Symptoms.	*Probable Area of Cortex Involved.*	*Points where Brain should be Uncovered.*	*Remarks.*
Facial spasm or paralysis.	Lower third of central region, especially in ascending frontal and posterior end of second frontal convolutions. The anterior part of this area seems to control chiefly the motions of the upper part of the face; and the posterior part the motions of the lips and mouth.	In front of lower third of fissure of Rolando, though the posterior edge of opening should be close to the line of the fissure of Rolando.	Aphasia is often associated with the facial symptoms.
Aphasia.	Below and in front of lower end of fissure of Rolando, varying somewhat with form of aphasia: 1. Sensory aphasia in first temporal sphenoidal convolution. 2. Motor aphasia in posterior part of third frontal and lower part of ascending frontal convolution. 3. Aphasia of incoördination in vicinity of island of Reil. Aphasia in right-handed persons is due to lesions on left side of brain; in left-handed persons, to lesion on right side of brain.	About 1.25 centimetres below and 1.25 centimetres in front of the lower end of the fissure of Rolando.	Single large opening will cover the convolutions for the three forms of aphasia, but the area for the third form is deeply situated in the fissure of Sylvius.
Associated brachial and facial spasm or paralysis.	Convolutions involved are those of arm and face, as given above.	In front of junction of middle and lower thirds of fissure of Rolando.	
Associated brachial and facial spasm or paralysis with aphasia.	Convolutions involved are those of arm, face, and speech, as given above.	In front of lower third of fissure of Rolando; and to be extended upwards, or downwards and forwards, according as brachial and aphasic symptoms are more pronounced.	
Associated facial spasm or paralysis and aphasia.	Convolutions involved are those of face and speech, as given above.	About 1.25 centimetres directly in front of the lower end of the fissure of Rolando; and to be extended upwards and backwards, or downwards and forwards, according as facial or aphasic symptoms are more pronounced.	

TABLE IV.—MORE UNCERTAIN LOCALIZATIONS.

Hemi-hyperæsthesia, Hemi-anæsthesia, Hemi-analgesia.	Behind fissure of Rolando in ascending parietal, and first and second parietal convolutions.	Behind the middle fissure of Rolando, and to be extended backwards rather than forwards.
Crural mono-hyperæsthesia, Crural mono-anæsthesia, Crural mono-analgesia.	Upper third of ascending parietal convolution and portion of parietal convolutions just behind.	Behind upper third of fissure of Rolando.
Hyperæsthesia of both legs, Anæsthesia of both legs, Analgesia of both legs, (Not due to spinal lesion).	Same region as in case above, but on both sides of the brain.	Over middle line behind the upper ends of both fissures of Rolando, to be extended towards the side of the vault of cranium opposite to the more pronounced symptoms. Take care to avoid, if possible, injury to superior longitudinal sinus.
Brachial mono-hyperæsthesia, Brachial mono-anæsthesia, Brachial mono-analgesia.	In middle third of ascending parietal convolution and portion of parietal convolutions just behind.	Behind middle third of fissure of Rolando.
Associated crural and brachial mono-hyperæsthesia, Associated crural and brachial mono-anæsthesia, Asociated crural and brachial mono-analgesia.	Upper two-thirds of ascending parietal convolution and portion of parietal convolutions just behind.	Behind middle two-thirds of fissure of Rolando.
Facial hyperæsthesia, Facial anæsthesia, Facial analgesia.	Lower third of ascending parietal convolution and portion of parietal convolutions just behind.	Behind lower third of fissure of Rolando.
Associated brachial and facial mono-hyperæsthesia, Associated brachial and facial mono-anæsthesia, Associated brachial and facial mono-analgesia.	Lower two-thirds of ascending parietal convolution and portion of parietal convolution just behind.	Behind lower two-thirds of fissure of Rolando.

TABLE IV. — MORE UNCERTAIN LOCALIZATIONS. (*Continued.*)

Loss or change in powers of attention, reason, judgment, or self-control.	Frontal lobes.	Surface of frontal bone, but the spot could only be located by some other symptom which might be present, such as aphasia or ocular deviation, affections of the leg or arm.
Muscular deviations of the eye and dilatation of the pupil.	In first and part of the second frontal convolutions in front of the motor centre for arm, reaching nearly to the longitudinal fissure.	About three centimetres in front of spot for exposing motor centre of arm.
Blindness, or failure to recognize and remember familiar objects, or hallucinations of vision.	Occipital lobes near parietal lobes, not far from angular convolution. Blindness of half field of both eyes at *right* side of body indicates destruction of *left* lobe, and vice versa.	About seven centimetres above the external occipital protuberance and seven centimetres around the skull laterally.
Deafness, or hallucinations of hearing.	First temporo-sphenoidal convolution of side opposite to affected ear. Failure to recognize or remember *spoken* language is a form of aphasia (sensory aphasia), and is due to lesion in first temporo-sphenoidal convolution.	Just below and about three centimetres behind the lower end of the fissure of Rolando.
Loss or hallucinations of smell.	Probably at base of brain in temporo-sphenoidal region.	Not accessible to operation.
Loss or hallucination of taste.	Not located.	